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The Venturi-Mucker

Don A. Rohrenbach

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Mining 68

Mining Engineering

A Thesis

Submitted to

Professor K.S. Stout

THE VENTURI-MUCKER

By

Don A. Rohrenbach

May 19, 1955

Montana School of Mines

Mining 68
Mining Engineering

*First Prize
National A.S.M.E.
Competition
1955*

A Thesis
Submitted to
Professor K. S. Stout

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THE VENTURI-MUCKER

by

Don A. Rohrenbach

May 19, 1955

Montana School of Mines

513 South Idaho
Butte, Montana
May 19, 1955

Mr. Koehler S. Stout
Assistant Professor of Mining
Montana School of Mines
Butte, Montana

Dear Mr. Stout:

I hereby respectfully submit my thesis, The
Venturi-Mucker, in partial fulfillment of
Mining 68.

This paper discusses the research and development
of a possible shaft mucker, which I call the
Venturi-Mucker. Results obtained from my research,
indicate that this devise may actually solve one
of mining's biggest problems, shaft mucking.

Very truly yours,

Don A. Rohrenbach

Don A. Rohrenbach

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I would like to express my appreciation of those people who so kindly gave of their time and advice to the preparation of this paper.

In particular, I would like to thank Professor Koehler S. Stout, whose guidance has been the keystone to success; Mr. Lloyd Pollish, who so generously gave of his time and effort; and the Research Department, Anaconda Copper Mining Company, Butte, Montana, which provided the necessary tools for research.

INTRODUCTION

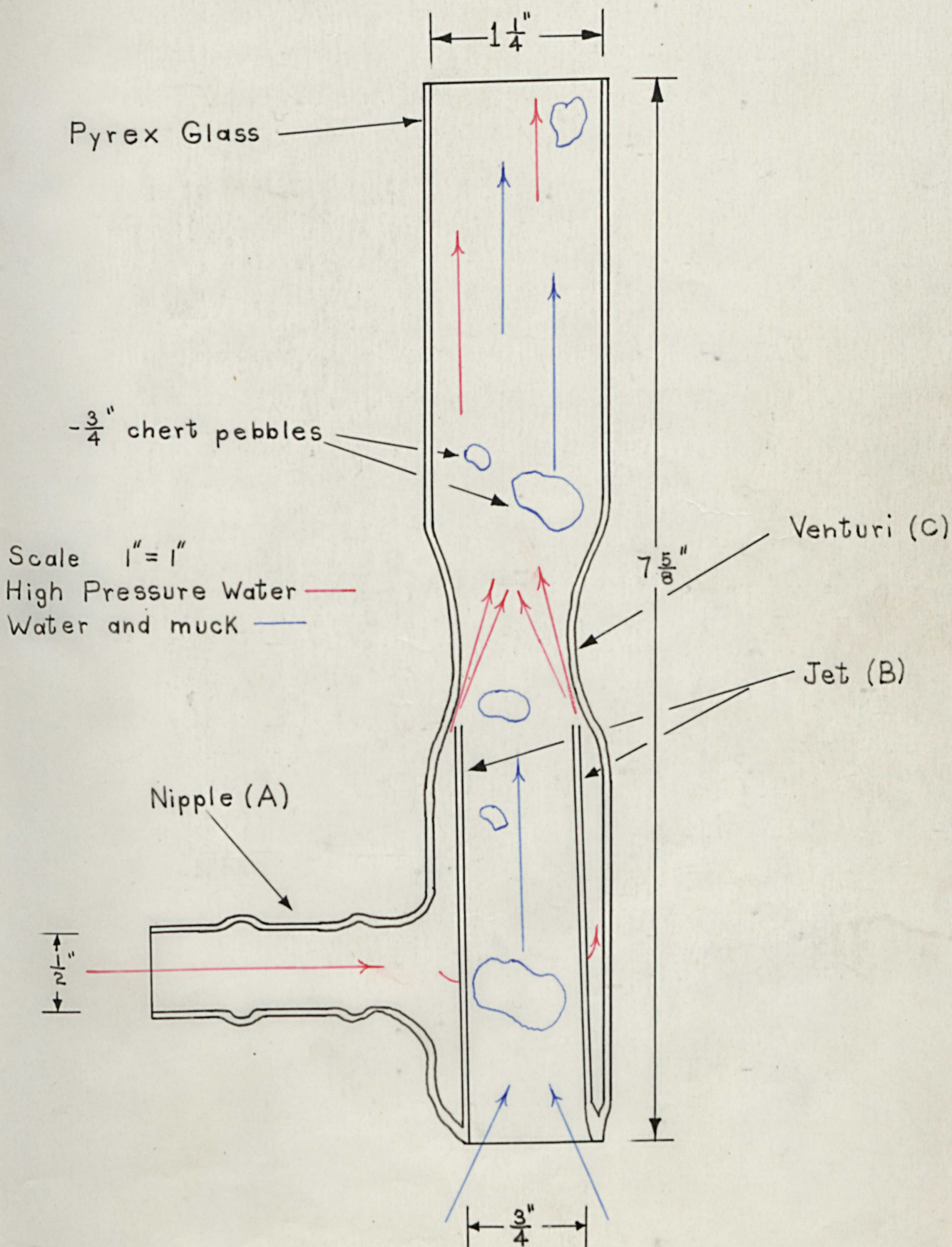
Shaft sinking has been and still is one of the biggest bottlenecks in any mining operation. Consequently, the shaft is by far the most expensive and time-consuming excavation of any development program.

When the shaft-sinking problem is broken up into its components, it is found that shaft mucking represents the largest fraction, both costwise and timewise. Since the mucking operation is the most important part of shaft sinking, it is, then, the most logical place for the introduction of cheaper methods. In response to this need, many mechanical devices have been developed for shaft mucking. These devices -- clamshells, scrapers, shovels, etc., -- have met with varying degrees of success; and in many cases, operators have discarded these machines and returned to hand mucking.

The present mechanical muckers have two basic flaws in common. First of all, they are not continuous flow machines; resultantly, there is not a continual flow of muck from the bottom of the shaft to storage bins or skips. Secondly, these muckers cannot completely clean the bottom of the shaft; this last 3 to 5 in. of muck usually must be removed by hand. When fully developed, the Venturi-Mucker will not be hindered by these two basic flaws.

Figure 1.

Crossection of Model No. 1.



THEORY OF OPERATION

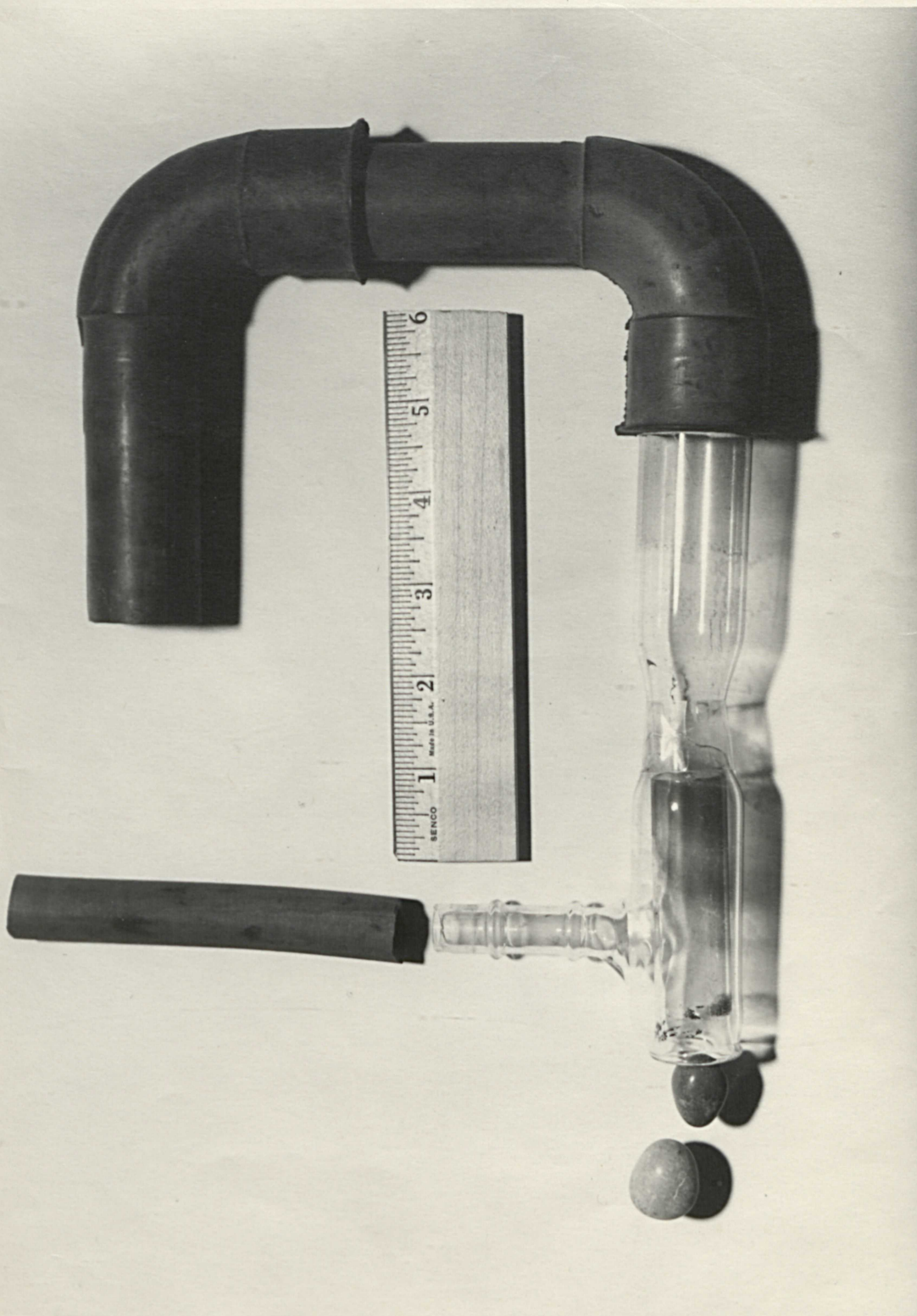
The Venturi-Mucker uses the same hydraulic principles as those employed in the low commercial Jet Pump. My first glass model (Figure 1) can best describe the fundamental principles governing the mucker.

The operation of the mucker can best be described as follows. High-pressure water is introduced through the nipple (A) and around the jet (B) of the model (Figure 1). When the water enters the throat of the venturi (C), this pressure head is then converted to velocity head. This conversion causes a suction, which operates the mucker by pumping the water and muck through the jet. The combined streams of water and muck move up and through the venturi of the model, and the velocity head is then converted back to pressure head.

The Venturi-Mucker is certainly the simplest type of mucker imaginable, for it has no moving parts such as shafts, gears, valves, or bearings.

Figure 2.

Photograph of Model No. 2.



MODEL 1

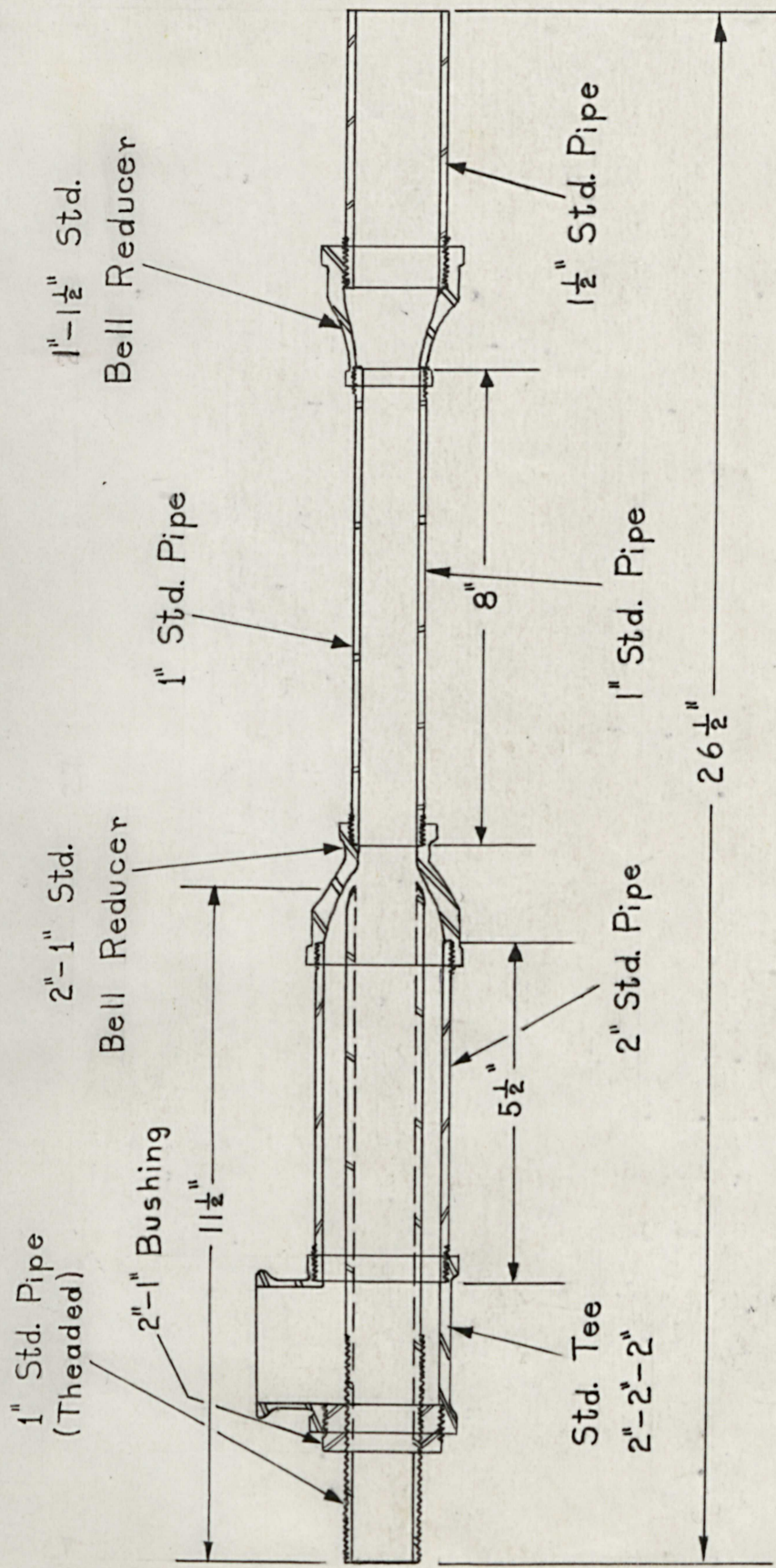
This model (Figure 2), fabricated by Professor Ruggles, of the Chemistry Department, Montana School of Mines, was constructed, for the most part, of pyrex glass. The jointed rubber fittings and the 1/2-in. rubber hose were obtained from the Mineral-Dressing Department. Power for the model was supplied by regular city tap water, and the experiments were performed in the Petroleum Laboratory, Montana School of Mines.

The mucker seemed to pump the best when the flow was 8 gpm. The muck, which in this case was minus 3/4-in. chert pebbles, was picked up with comparative ease at this flow.

Mr. Stout, Professor of Mining, and myself believed that the results obtained were significant enough to warrant building another larger model, but there was a question concerning the finance of such a research project. We finally decided to present our problem to Mr. L. F. Bishop, Research Engineer, Anaconda Copper Mining Company, Butte, Montana. The final result of our meeting was the acceptance of the problem as a research project for the Department. All of the research in the remainder of this report was done in conjunction with Mr. Lloyd Pollish, Assistant Research Engineer for the Anaconda Copper Mining Company.

Figure 3.

Crosssection of Model No. 2



Scale 1" = 3"

MODEL 2

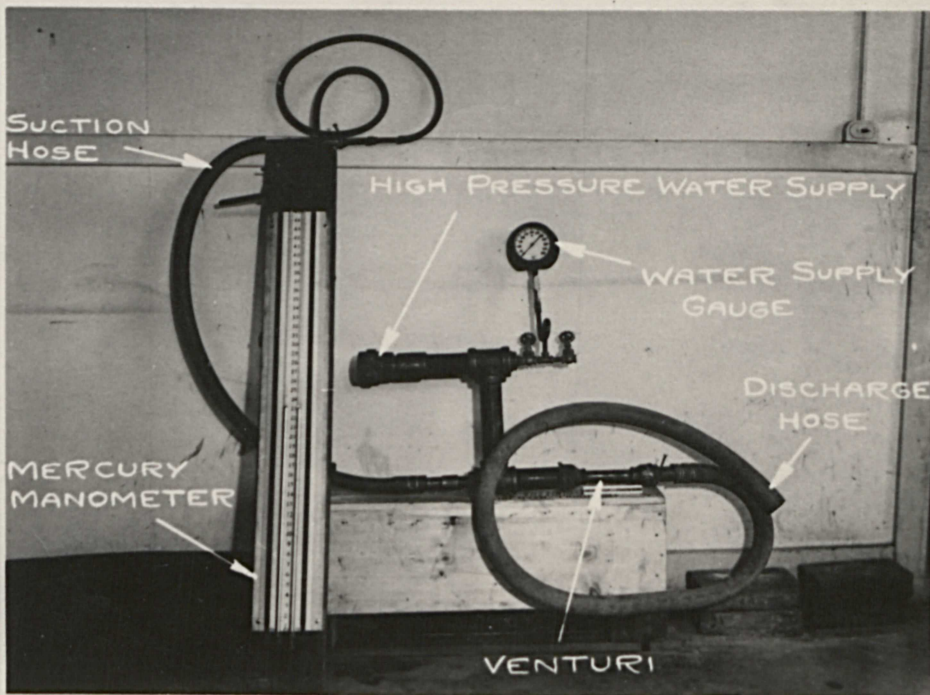
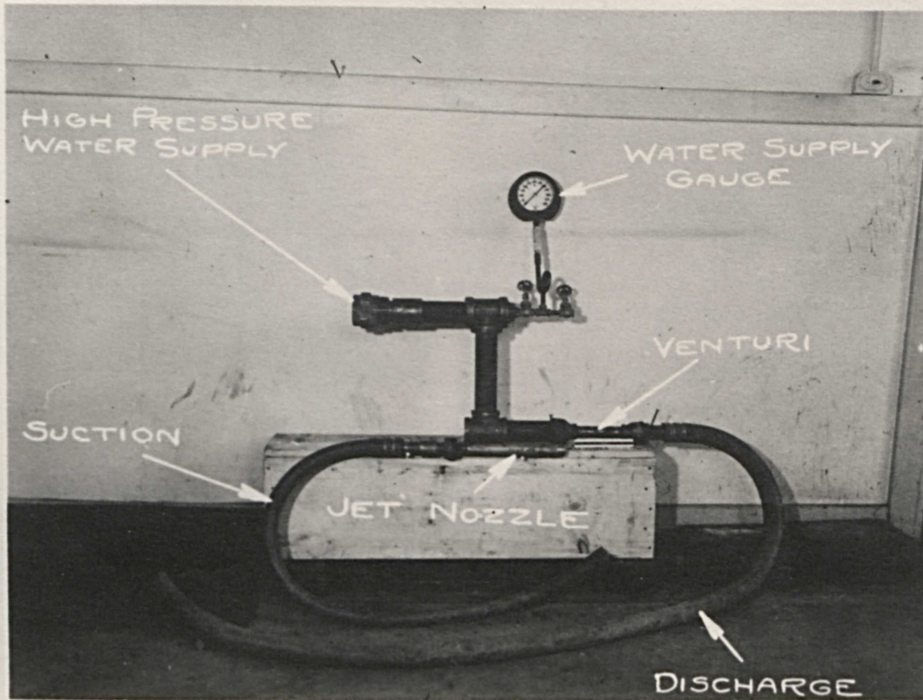
The second model (Figure 3) was constructed to serve two general purposes: first, we needed a model which would be durable enough to withstand considerable experimentation; next we needed some ideas pertinent to the design of a larger and perhaps a more efficient Venturi-Mucker.

The model consists of a 1-in. threaded pipe $11\frac{1}{2}$ in. long, a 2-to-1-in. bushing, a 2-in. tee, a 2-in. threaded pipe $5\frac{1}{2}$ in. long, a 1-to- $1\frac{1}{2}$ in. bell reduced, and a $1\frac{1}{2}$ in. threaded pipe 6 in. long. The jet in this case is represented by the 1 in. threaded pipe $11\frac{1}{2}$ in. long, as noted. The two bell reducers, along with the 1 in. pipe, represent the venturi of the model. All of these fittings are of standard make.

Completely equipped, the model is shown in Figure 4 by two labelled photographs. The extra equipment was, of course, needed for the collection of data. This equipment consists of a 1-in. suction hose 4 ft. long, a $1\frac{1}{2}$ in. discharge hose 8 ft. long, a pressure gage with its necessary valves, a mercury manometer, and a 2 in. fitting for the installation of the model to the high-pressure water supply.

Figure 4.

Photographs of Model No. 2.



Power for Model 2 was supplied by a fire hydrant, which is situated next to the Never-Sweat Shaft. A 60 gallon tank, pictured in Figure 6 was used for the measurement of the flow and the pumping capacity of the mucker.

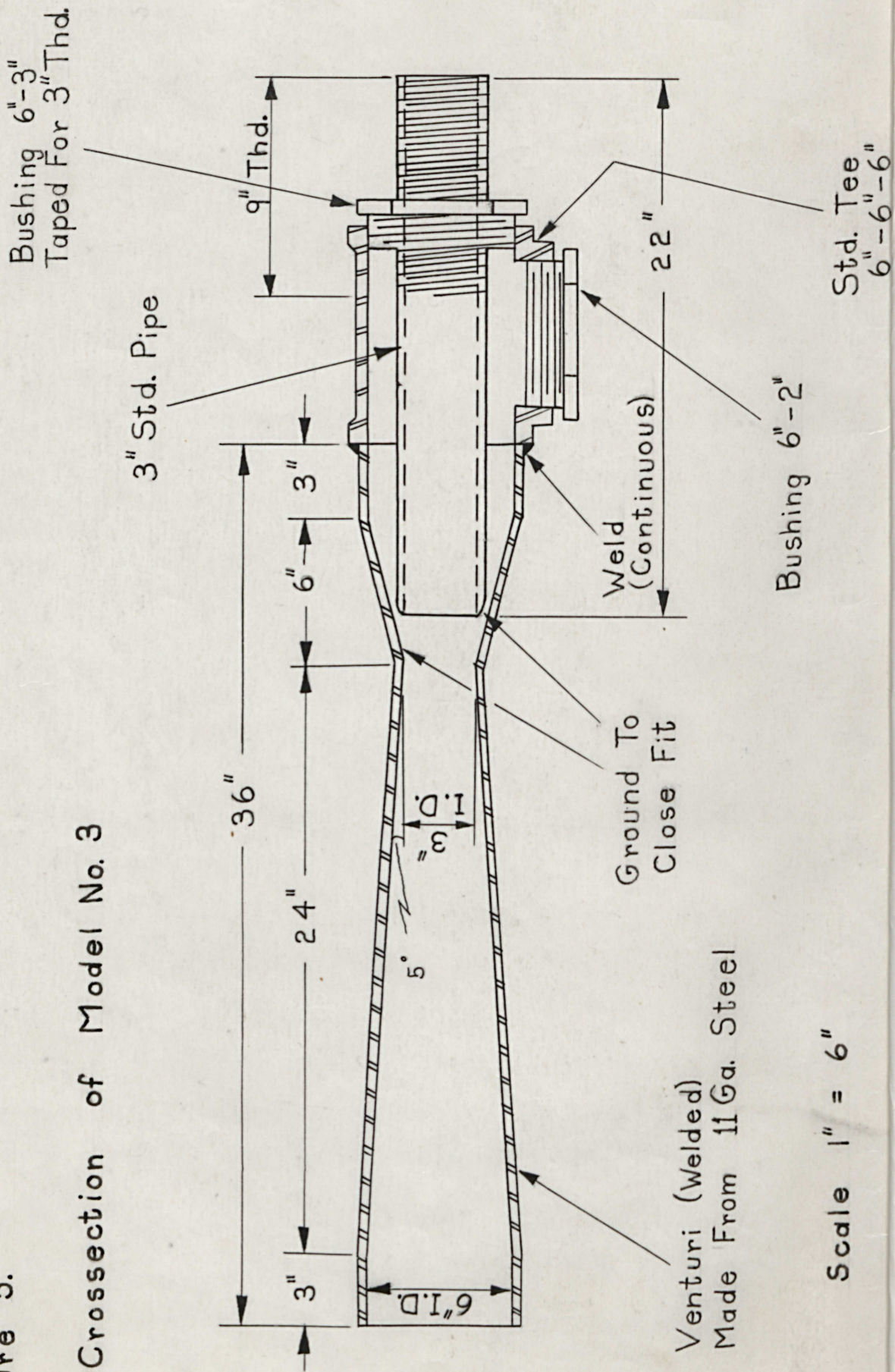
The results of our tests with the second model of the Venturi-Mucker are listed below.

Test No.	Time to fill tank	Time to empty tank	Pressure (psi)	Vacuum inches Hg	Ratio of water required to water pumped
1.	1'15"	2'25"	126	15	1 : : .52 .515
2.	1'15"	3'25"	100	15½	1 : : .366 .366
3.	2'15"	2'00"	135	10	1 : : 1.12 1.125
4.	2'00"	1'15"	135	24	1 : : 1.6 1.6
5.	1'35"	1'10"	137	21	1 : : 1.267 1.36
6.	2'25"	1'25"	137	21	1 : : 1.817 1.71

By examining the table, one can see that Tests 4 and 6 contain our best results. The ratio between the flow of water required and the amount of water pumped was from 1 to 1.6 and from 1 to 1.81, respectively, for these two tests. In other words, for every gallon of high-pressure water introduced into the Venturi-Mucker from 1.6 to 1.81 gallons were pumped. We ran both of these tests when the jet of the model was adjusted at 1/4 turn open.

Figure 5.

Crossection of Model No. 3



Scale 1" = 6"

The only change in design which was tried in Model 2 was the replacement of the 1 in. pipe 8 in. long, between the two bell reducers, by a 1 in. pipe 4 in. long. The shorter pipe undoubtedly caused considerable turbulence, because the manometer registered a definite drop in the suction.

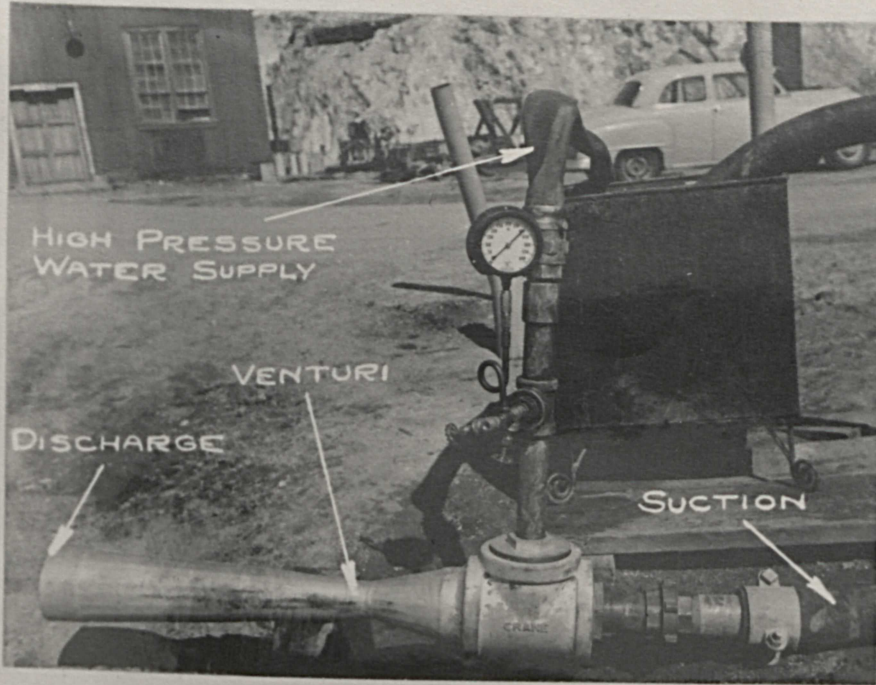
The favorable results obtained from this crude model lead us to believe that a so-called streamlined model would even produce better results.

MODEL 3

The venturi of Model 3 (Figure 5) was designed according to the specifications found desirable in venturi-flow meters. It is believed that a minimum friction loss is obtained for an angle of about 5 deg on the discharge side of the venturi. Consequently, our venturi has a downstream angle of 5 deg. The diameter of the throat of the venturi is 3 in., whereas the diameter of the discharge is 6 in. The venturi, which is 3 feet long, is made from rolled 11-gage steel. Fabrication of this portion of the mucker was done by the Western Boiler and Machinery Company of Butte, Montana. The remaining portion of the model was produced in the Butte shops of the Anaconda Copper Mining Company.

Figure 6.

Photographs of Model No. 3.



We ran a rather brief series of tests with this model, whose results did not all compare with those obtained in our second model. The mucker did, however, pump 350 gpm at 13 in. of mercury; but the jet had to be opened so wide that the pressure reading was 0. All of these data were collected from the setup pictured in Figure 6.

Upon examination of those tests in which no or very little pumping occurred, we discovered that the cone of water being discharged around the jet converged very closely to the end of the jet. We also reasoned that the venturi throat was not a desirable place for the production of the proper elongated cone.

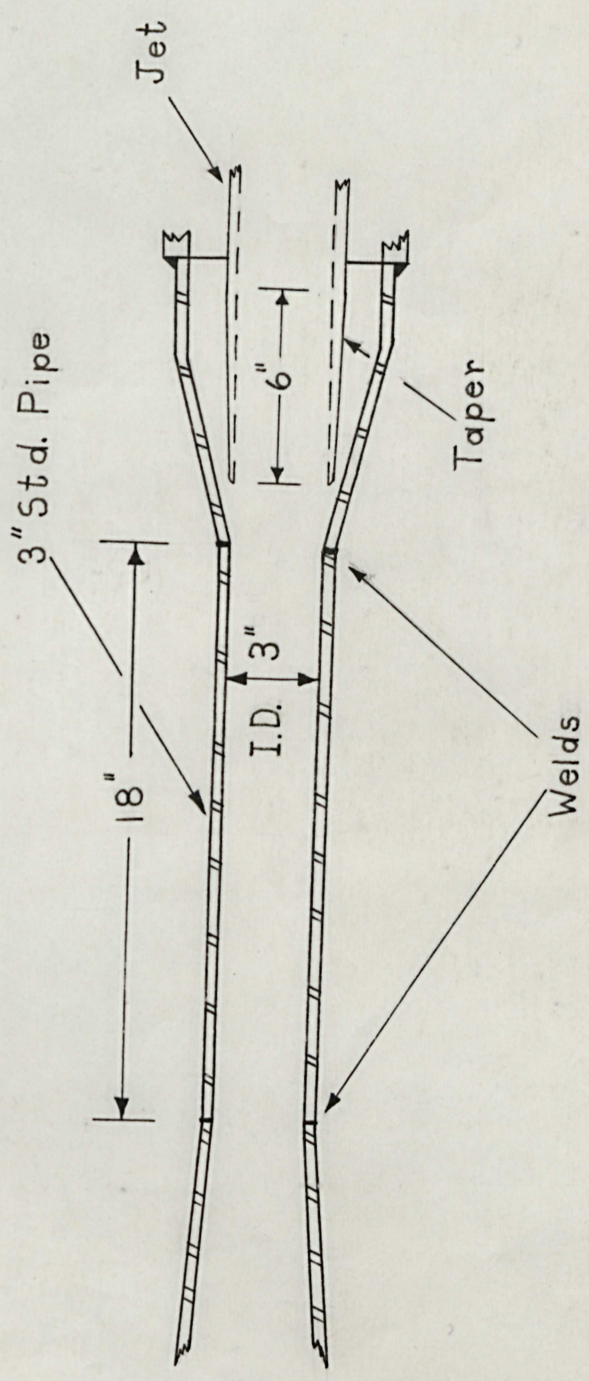
Our next step was the redesigning of this model into our fourth and final mucker.

MODEL 4

That portion of Model 3, which was redesigned, is shown in Figure 7. We made two basic changes on this previous design. First of all, we had the jet turned down on lathe, the taper starting 6 in. back from the end of the jet. By so doing, we hoped to produce a stream of water which would form the desirable elongated cone. Next, we cut the throat of the venturi and welded a straight piece of 3 in. pipe,

Figure 7.

Partial Crossection of Model No. 4



Scale 1" = 6"

18 in. long, between the two pieces. We hoped that this straight piece of pipe would serve as a better reservoir for the low-pressure cone.

The same testing procedures and apparatus as those depicted in Figure 6 were used in the experiments with this redesigned model. The results of our tests with this model of the Venturi-Mucker are listed below.

Test No.	Time to fill tank	Time to empty tank	Ratio of water required to water pumped	Pressure (psi)	gpm Suction	gpm Dis.	theor HP
1.	45"	11"	1 : : 4.1 4.1	125	327	407	5.6
2.	15"	6"	1 : : 2.5 2.5	100	600	840	9.2
3.	23"	7"	1 : : 3.3 3.3	110	514	670	8.1

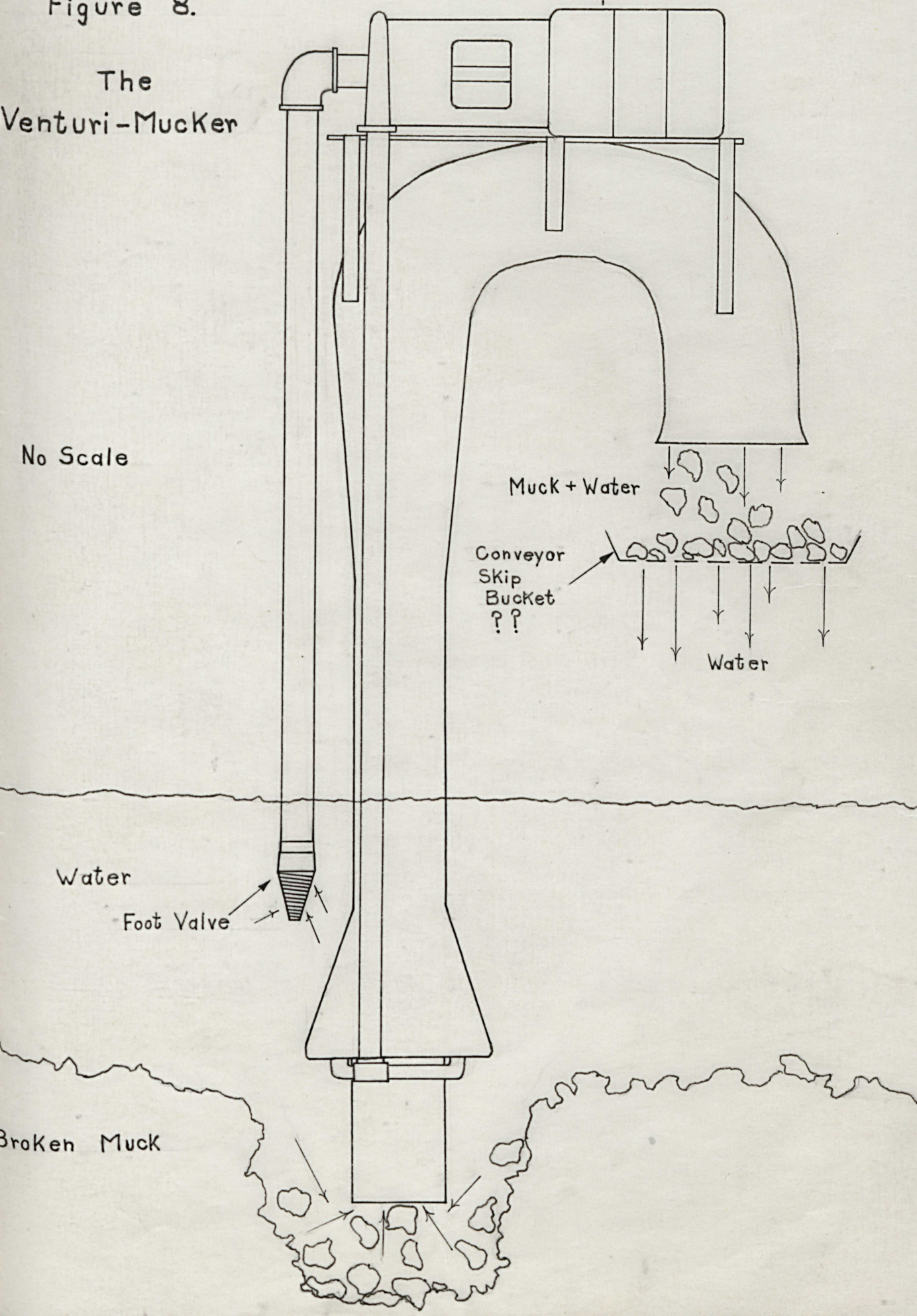
Besides those tests whose results I have already listed, we undertook other experiments. These tests involved filling the 60 gallon tank 1/4 full of dirt, gravel, bricks, and small pieces of scrap iron. The remainder of the tank was filled with water, the tests being run as already outlined. Material in the tanks was almost completely removed by the suction of the mucker. The remaining material would also have been removed, but the capacity of the tank is so small that the water was pumped out in a matter of seconds.

Motor-Pump

Figure 8.

The
Venturi-Mucker

No Scale



APPLICATION

Figure 8 portrays a possible setup of the Venturi-Mucker in the bottom of a shaft. A carriage, such as that used by the Riddell mucker arrangement, could be effectively used to move the whole unit around the shaft bottom. Another arrangement could involve a stationary mucker with a flexible suction hose, as in Models 2, 3 and 4.

The advantages of the Venturi-Mucker may be described as follows:

1. There will be a continual flow of the muck from the shaft bottom to skips or some other type of conveyance.
2. It could be used in the wettest or the driest shaft.
3. Only a few men will be needed to operate this mucker.
4. All of the muck will be removed from the bottom of the shaft.
5. The mucker has simplicity of design.

Fragmentation, of the shaft round, is one of the keys to the success of the Venturi-Mucker. It is hoped, however, that this system will prove of sufficient value to warrant the development of a shaft round which will consistently break all the muck to minus 6 in. Therefore, the diameter of jet or suction hose of the final model should be 7 in.

CONCLUSION

Our experiments indicate that the Venturi-Mucker is practical. Increased tolerance in design will probably increase the efficiency of future models. The size of the model is the only limiting factor for the size of the muck.

The Anaconda Copper Mining Company is planning on using a device similar to Model 4 for pumping slimes in their slime fill program. Their research will undoubtedly point out even more improvements in design.



AMERICAN INSTITUTE OF MINING & METALLURGICAL ENGINEERS

29 WEST 39TH STREET

NEW YORK 18, N. Y.

December 6, 1955

Library
Montana School of Mines
Butte, Montana

Dear Sir:

As was requested by Mr. Clifford J. Hicks, Secretary of the Montana Section of AIME on July 1st, we are returning herewith the paper submitted by Mr. Don A. Rohrenbach in our Student Prize-Paper Contest.

Mr. Rohrenbach's paper was adjudged one of the winners in the final analysis.

Sincerely yours

H. N. Appleton
(ref)
H. N. Appleton
Assistant Secretary

HNA:rcf
enc.
c/c C.J.Hicks

RULES AND PROCEDURES OF THE
AIME ANNUAL STUDENT PRIZE-PAPER CONTEST

A. PURPOSES

The purpose of the Student Prize-Paper Contest is to serve the interest of students associated with AIME by:

1. encouraging them to prepare papers on subjects of interest in the mining, metallurgical, and petroleum industries.
2. offering them the opportunity to demonstrate their ability as technical writers to the universities, industry, and the Institute.
3. presenting cash awards to contest winners for their accomplishments.

B. AWARDS

1. Authors of the three best papers in the undergraduate division are awarded \$100.00 each at the AIME Annual Meeting.
2. Authors of the three best papers in the graduate division are awarded \$100.00 each at the AIME Annual Meeting.

C. QUALIFICATIONS FOR AUTHORS

1. Undergraduate Division
Only Student Associate members of AIME are eligible to enter papers in the undergraduate division.
2. Graduate Division
Student Associates, or Junior Members of AIME who are at least half-time students, who are candidates for a Master's Degree are eligible to enter papers in the graduate division.

D. RULES GOVERNING FORM AND CONTENT OF PAPERS

1. The papers entered in the prize-paper contest shall represent as completely as possible, the original work of the author in planning the investigation, in interpreting the results, and in drafting the papers.
2. The subjects of papers entered in the prize-paper contest must relate to some phase of mining, metallurgical, or petroleum engineering.
3. Each paper shall be prepared by a single author.
4. Each paper shall be typewritten (by the author or under his supervision), double-spaced, on commercial paper (8 $\frac{1}{2}$ "x11") of good grade. The paper shall not contain less than 2000 or more than 4000 words.
5. Illustrations, if used, must be in form suitable for reproduction.
6. Papers entered in the prize-paper contest shall not have been published previously.

E. PROCEDURES FOR ENTERING THE STUDENT PRIZE-PAPER CONTEST

1. When the Local Section conducts section prize-paper contests, students shall submit their entries through the Faculty Sponsor to the Secretary of the Local Section for review in accordance with the rules of the Local Sections and transmittal, if judged of sufficient merit to AIME headquarters, for consideration by the Student Prize-Paper Committee.

2. When the Local Section does not conduct section prize-paper contests, students shall submit their entries through the Faculty Sponsor to the Secretary of the Local Section who will arrange for their review or their transmittal without section review to AIME headquarters for consideration by the Student Prize-Paper Committee.

F. LOCAL SECTION PRIZE-PAPER CONTESTS

1. Local Section prize-paper contests shall be conducted in accordance with rules established by the sections.
2. Prizes offered by the Local Sections are the concern of the Section, but funds for prizes may not be drawn from the Section allotment from the National Institute Treasury.
3. Judges of Local Section prize-paper contests shall, in general, follow the rules for the National Student Prize-Paper Contest.
4. The number of papers which shall be submitted by any Local Section for consideration by the Student Prize-Paper Committee shall be determined as follows:
 - (a) Not more than three if the Section receives papers from one Student Chapter;
 - (b) Not more than one additional for each additional Student Chapter which submits papers to the Section for review.A Section with four participating Chapters would be authorized to submit six papers.

G. CONTEST DEADLINES

1. The Local Section secretaries shall forward papers entered in the prize-paper contests so as to reach AIME headquarters not later than September 1.
2. The Local Section secretaries shall establish appropriate deadlines for the entry of papers in the Local Section prize-paper contests.

H. DIRECTIONS FOR TRANSMITTAL OF PAPERS

1. Papers entered in the prize-paper contest shall be transmitted to:
Mr. H. Newell Appleton, Asst. Secy. for Activities
AIME
29 West 39th Street
New York 18, New York

I. PROCEDURE FOR SCREENING AND REVIEWING PAPERS.

1. Papers shall be screened at AIME headquarters to establish the eligibility of the authors and the paper under the rules of the contest.
2. AIME headquarters will acknowledge receipt of papers and distribute them to the Chairman of the Student Prize-Paper Committee or the committee member designated as chief reviewer in a particular field.
3. The Student Prize-Paper Committee shall determine the three best papers in the Undergraduate and Graduate Division, announce the award winners during the next succeeding Annual Meeting of the Institute, and present the Awards.